INTERIM STATE DROUGHT MANAGEMENT PLAN
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Office of Water Management
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INTRODUCTION

The State Interim Drought Management Plan reflects the current thinking of the Tennessee Office of Water Management on the planning and management of water during periods of drought. Certain actions are best performed by state agencies; however, much of the burden of drought planning rests on individual public water suppliers, industries, farmers and individual users. This document guides each group on the advanced planning necessary to prepare for drought and on what the Office of Water Management envisions as its management role in a drought.

Both water quantity and water quality are affected by drought. These are major concerns of the Office of Water Management, reflecting the agency's mandates to protect water quality and to insure the provision of safe drinking water. In accordance with these mandates, this plan recommends that every water user consider all management alternatives based on a thorough evaluation of water sources, facilities and uses of water. Because drought affects each user differently, responses of municipalities, utility districts, businesses, farmers and others to a drought will vary. Because circumstances and needs differ, the role of the state is to provide guidance as well as assist in coordinating efforts. Local suppliers and users of water are best able to formulate management strategies to deal with local needs and avert further adverse impacts. Conflicts among local suppliers and users involving water rights will be handled by the state on an emergency, case-by-case basis.

Need For A Drought Management Plan

The development of an Interim State Drought Management Plan is based on several related mandates in Tennessee statutes. These are the Water Resources Division Act of

1957, which authorizes the Department to provide general direction in all matters pertaining to the conservation, protection and development of Tennessee's waters, including the development and implementation of a basic, long-range water resources policy; the Tennessee Safe Drinking Water Act of 1983, which requires development of a plan for the provision of safe drinking water under emergency circumstances; and the Tennessee Water Quality Control Act of 1977 as amended, under which the Water Quality Control Board has adopted a plan for the protection and preservation of the state's waters.

The need to develop an interim plan, defining the roles and responses of agencies under water shortage conditions, is evident considering the drought impacts experienced over much of the state. In addition, recent studies of drought-related impacts on systems and of water rights have indicated the need for local water resources development, emergency planning and clarification of current state, federal, local and private responsibilities and authorities. This is the Department of Health and Environment's interim plan for the management of water under drought conditions. It also serves as the emergency water management plan authorized under the Tennessee Safe Drinking Water Act (T.C.A., Section 68-13-710).

Plan Overview

This interim plan is organized from a broad management perspective to provide guidance to those users having limited supplies due to facility design, inadequate sources and/or water quality problems due to diminished streamflows.

Users are urged to evaluate their water sources, anticipate availability problems, evaluate treatment and delivery capacities and identify essential needs. Although risk of water

shortage will always be present, the toleration of risk will vary among users. Users should develop plans for managing resources and needs based on a level of risk acceptable to them.

Actions identified in this plan are grouped by user category as well as by the drought conditions experienced. For example, communities already experiencing a severe or critical water shortage would skip the "conservation" and "restrictions" phases and focus on those responses identified under the "emergency" phase.

Remedies identified in the "conservation" and "restrictions" phases are actions which are to be implemented under less critical drought conditions. Plans and policies which are acceptable to the community should be developed under the different phases of drought. The goal of a user or community is to insure the availability of water to all users under deteriorating conditions as fairly and reasonably as possible.

"Emergency" responses generally consist of those actions needed to address severe or potentially severe water supply or water quality problems. Emergency actions almost always require resources, particularly monies, which are not otherwise available. Although there are few options to water users in an emergency situation, emergency actions can be planned in order to avoid unnecessary expense.

The Drought Responses and Roles section of this interim plan further defines the roles of various water users and managers. The Commissioner of the Department of Health and Environment advises public water suppliers and other local users to develop their own response plans. **Each plan should detail responses which are "phased" to address increasingly severe drought conditions. Recommended phases should include a "conservation" phase, a "restrictions" phase and an "emergency" phase.** The plan should

consider source capacity, a facility's hydraulic limitations, how water is used and possible water quality problems due to lower than usual flows. Specific actions included in the plan under each phase depends upon local circumstances and needs and the acceptability of remedies to deal with those needs. An extensive list of potential drought responses for various types of users is contained in the interim plan.

Problems and needs that are regional or statewide should be addressed by agencies having a state or regional water management responsibility. Some problems may be beyond the state's authority or ability to manage or may have a national impact. The chart "Drought Responses," located on the next page, identifies the roles of agencies under various drought scenarios.

In summary, state and federal roles consist mainly of data collection, information dissemination, technical assistance and regulatory oversight. Where conflicts over water rights and water quality problems emerge or local situations become "emergency" situations, the Tennessee Office of Water Management, the Tennessee Emergency Management Agency and the Governor can enter the situation. Once a situation is declared an emergency, special actions can be taken under the Governor's emergency powers authority.

Drought Responses

Condition and Program Phase	State and Federal Actions	Local Actions		
		Public Water Suppliers	Industrial	Agricultural and Self-Supplied
Normal Conditions Water supply is adequate; water quality is acceptable under normal management	.Develop precipitation, streamflow, ground water, and water quality monitoring programs .Conduct state and regional water studies and coordinate recommended actions .Assist public water suppliers and local government in developing Emergency Water Management plans .Establish public education program	.Develop Emergency Water Management Plans .Develop additional storage and treatment facilities; evaluate distribution system .Adopt standby rates, other necessary ordinances and codes, and establish mutual aid agreements, interconnections, conservation education, etc.	.Develop Emergency Water Management Plans .Develop additional wastewater storage .Develop alternative water supplies, water storage and conservation measures .Purchase standby equipment and install permanent equipment as necessary for recycling	.Develop county emergency management plans. .Evaluate need for irrigation .Enlarge ponds, purchase tanks, drill wells, install conservation devices and livestock watering tanks .Evaluate agricultural water use and find where conservation could be used, including use of "drip" irrigation .Evaluate domestic water use and install water-saving devices, etc. to reduce stress on supply source
Drought Alert Lower than normal precipitation, declining streamflows and groundwater levels; greater than normal demand	.State issues Drought Alert to media and notifies targeted water users (Alerts may be regional or local) .Intensify selected monitoring activities .State initiates an awareness program	.Monitor water sources and daily water use for specific purposes and anticipate user demand .Monitor potential conflicts and problems	.Monitor water sources and daily water use for specific purposes and anticipate demand .Monitor water quality	.Monitor water sources and daily water use for specific purposes and anticipate demand
Conservation Phase Water supplies/water quality deteriorating or conflicts among users	.Disseminate water supply and water quality data .Monitor systems and users having past problems and monitor plan implementation .Coordinate state and federal supply and water quality actions .Respond to local and individual appeals for assistance ."Post" streams where water quality standards are not met .Commissioner issues orders to water suppliers and/or dischargers	.Implement "conservation" phase at plan triggering point. Potential conservation measures include curtailment of outside uses, education, and pricing .If conservation goal is not obtained, implement restrictions .Notify OWM of source conflicts	.Institute re-cycling, cut-back production, store wastewater, alter production schedule per industrial water management plan during a drought .If goals are not met, implement additional measures .Notify OWM of source conflicts	.If assessed source is capable, irrigate crops .Provide tanks, etc. to meet water supply needs of livestock, fish, and aquatic life .Continue conservation of domestic supplies .Notify OWM of source conflicts
Restrictions Phase Continued decline in water supply and/or water quality	.Same responses as in Conservation Phase	.Implement "restrictions" phase at plan triggering point. Restrictions could include banning of some outdoor water uses, per capita quotas, cutbacks to non-residential users .Notify OWM of source conflicts	.Institute additional cut-backs in production, storage of wastewater, or changes in production schedule, etc., per industrial water management plan .Notify OWM of source conflicts	.Same responses as in Conservation Phase
Emergency Phase Severe water supply or water quality problems due to very limited resource availability	.Governor responds to critical situations by declaring an emergency .TEMA takes action .OWM mediates in conflicts of source utilization under emergency powers	.Notify TEMA and request emergency declaration .Provide bottled water and sanitation supplies to users .Make hospitals, firefighting, etc., priority .Initiate hauling of water .Comply with Commissioner's Orders	.Request emergency declaration of Governor .Comply with Commissioner's Orders .Request assistance from local government .Implement hauling water for sanitation, domestic uses	.Request local government assistance in obtaining water for domestic purposes, and in supporting livestock .Implement hauling water, etc.

RISK ASSESSMENT: ESSENTIAL TO DROUGHT RESPONSE PLANNING

Informed and prepared individuals, businesses and municipalities may already know their water source's capability and be prepared for times of diminished supply. Perhaps storage facilities have been constructed or emergency connections with a reliable alternative supply are in place. Or, conservation measures may have been planned because costs appeared to out-weigh advantages of other responses. Whatever the pre-emergency planning, users must first decide their acceptable level of risk for their source of water.

Although risk of water shortage will always be present, the toleration of risk will vary among users. Under severe drought conditions, making water available may involve considerable source and facility development. Considering costs, users develop facilities based on the level of risk acceptable to them.

The level of risk is based on source capability and the extent to which it has been developed. Once these are known, users must develop plans for managing resources and demands under drought conditions. The development of a drought management plan should provide an equitable degree of protection to users. For users with less developed sources and facilities, a management plan is an effective means for averting a water crisis during a short-term drought. Over an extended drought, however, effective management alone may not be sufficient. With more developed sources and facilities, a drought management plan can help avert a crisis during a drought of longer duration.

In order to assess the level of risk, users must know two things: the dependable capacity of their water source and their capability to deliver water under heavy demand. An adequate water source does no good if facilities cannot keep up with demand; adequate facilities do no good if water sources are unable to meet demand. A good supply depends

on both. The capacity of a water source is a result of localized, natural conditions and can be measured. Delivery of water depends on treatment capacity, delivery capability, storage and system management practices. Making a system more reliable entails greater expense.

Climatic And Hydrologic Variations

Users should first view the source within the context of the overall hydrologic cycle. Although Tennessee averages over fifty inches of precipitation each year, about thirty inches of that is taken up by evapotranspiration. (Evapotranspiration is the loss of water through transpiration of plants and evaporation from soil and other surfaces.) Figure 1, "Mean Annual Precipitation," and Figure 2, "Water Balance for Selected Tennessee Locations," show not only the normal variability of precipitation across the state, but also seasonal variation. Evaporative loss increases in the summer and fall when it is warm and plants are growing. About twenty inches either percolates into the ground recharging the ground water or runs off as streamflow. Winter and spring rains restore the ground water resource.

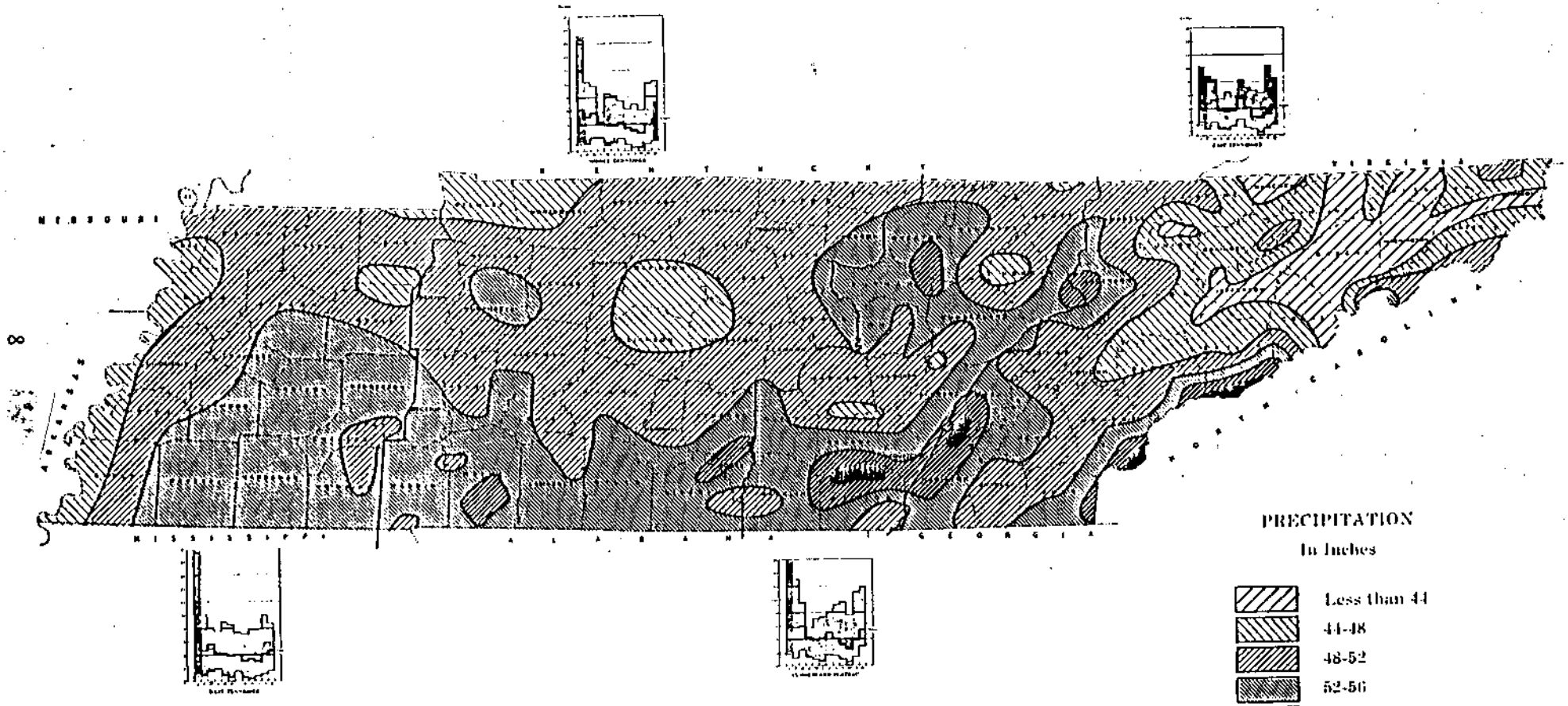
Ground water is especially important to maintaining streamflows during periods of low rainfall. Water entering the ground moves toward wells, springs and streams. Consequently, throughout the summer ground water slowly depletes itself to provide "base" streamflow. Although generally more reliable than streams, springflows and water well yields below seasonal levels can be expected in East and Middle Tennessee during extended dry periods. In West Tennessee, ground water yields from unconsolidated sands are typically less variable and more sustainable, because of larger aquifer storage capacity.

Figure 1

MEAN ANNUAL PRECIPITATION

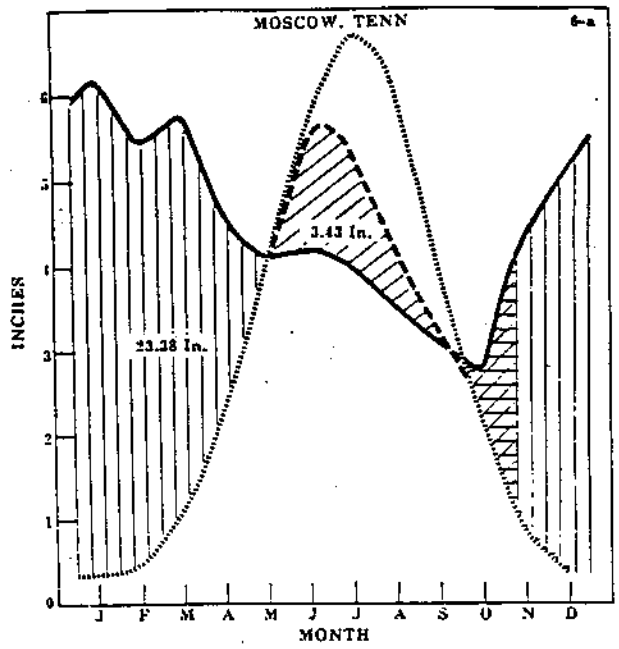
WITH MAXIMUM, MINIMUM, AND MEAN DIVISIONAL AVERAGES

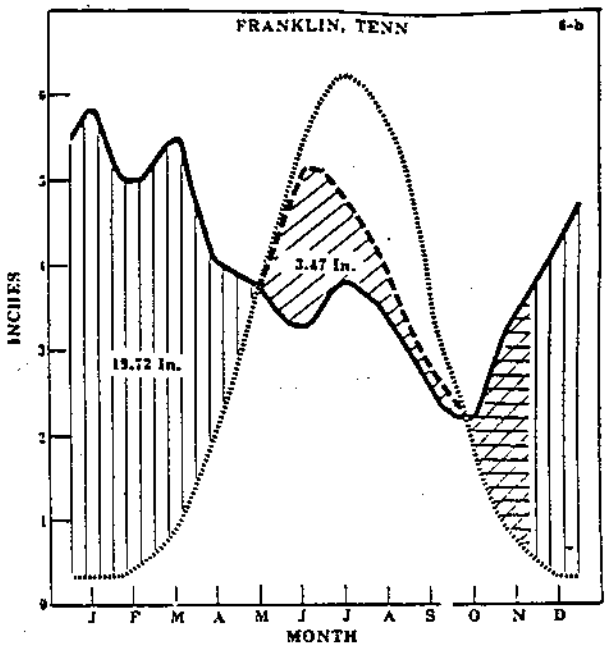
(1931 - 1955)

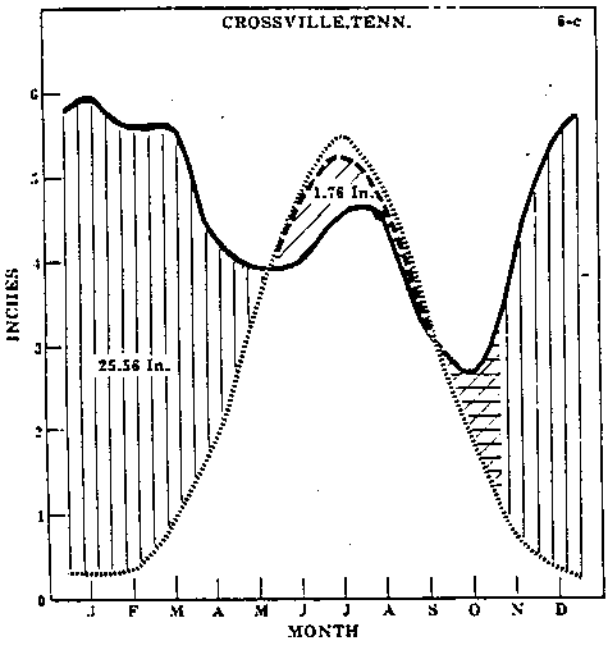


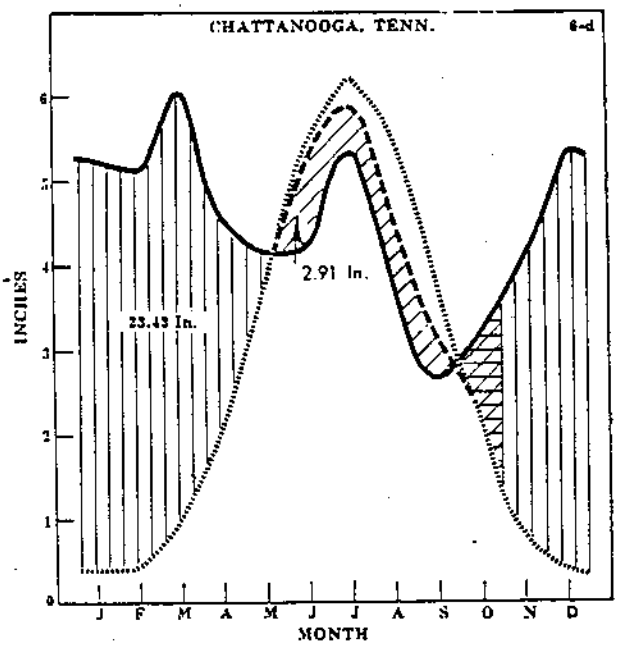
SOURCE: U.S. Weather Bureau

Ref: National Water Summary 1985 p. 427









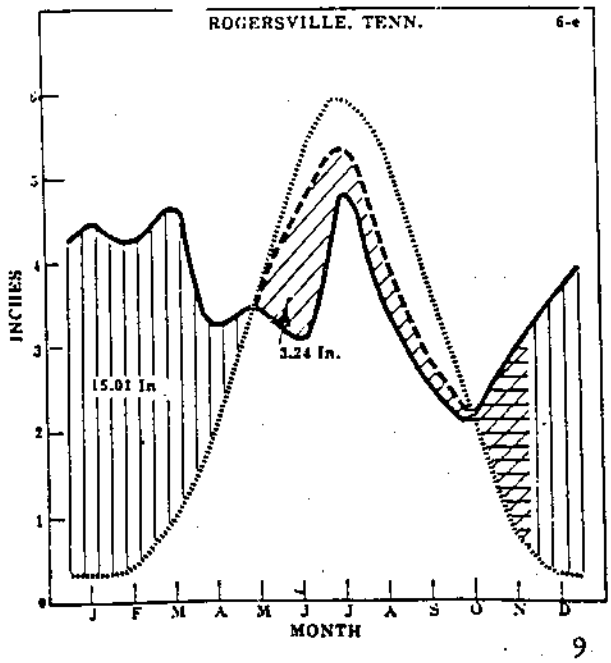
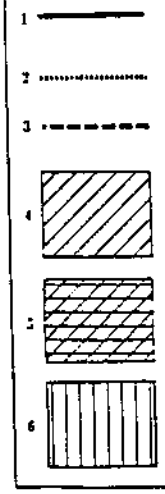


Figure 2



Water balance for selected Tennessee locations (1931 - 1955). Moisture conditions shown at end of each month. Maximum available soil moisture assumed 4 inches. Symbols are: 1. precipitation; 2. potential evapotranspiration; 3. actual evapotranspiration; 4. soil moisture loss; 5. soil moisture recharge; 6. surplus water.

The measurement of springs, wells and streamflows over a long period provides a statistical basis from which to predict flows and yields. The most frequently used low-flow statistic for unregulated streams and springs is a flow which can be expected to occur once in twenty years averaged over a three-day period. This hypothetical streamflow is referred to as a "3Q20". In water management the 3Q20 is used as a drought point in Tennessee. It is the degree of risk usually used in planning.

Pump tests are used to measure water well capacities. These tests, which involve detailed analysis of area geology and other factors, can be very informative. Reservoirs can be evaluated based on stream inflow, water level, usable storage capacity, evaporation and other information. Similarly, the Palmer Index is used to evaluate prolonged periods of unusually wet or dry weather. The Palmer Index describes a meterological rainfall shortage and may not exactly correlate with a water supply shortage. Measurement statistics used to compare the amount of available water from year to year are useful in the management of water. These data indicate the degree of risk a stream, spring or water well user may be assuming. The degree of risk of one source may not correlate well with other types of sources because of differences in the ways sources are replenished and used. For example, an "agricultural drought" occurs in years which have low rainfall during the growing season although the rest of the year may be wetter than normal. A near "normal" year in terms of precipitation, following a very dry year, may have lower ground water levels and reduced surface water flows although soil moisture conditions may be adequate for agricultural purposes. Users relying on ground water in these areas might experience a "ground water drought" under these conditions.

Droughts which develop over an extended period of time including winter and late spring generally result in limited ground water supplies over the eastern two-thirds of Tennessee

by late summer and fall, as well as limited surface water over the entire state. These conditions are frequently referred to as a "hydrologic drought." Thus, seasonal variation, antecedent conditions and topographic and geologic differences are important considerations in evaluating a source's reliability, its potential to assimilate waste and the management of its use.

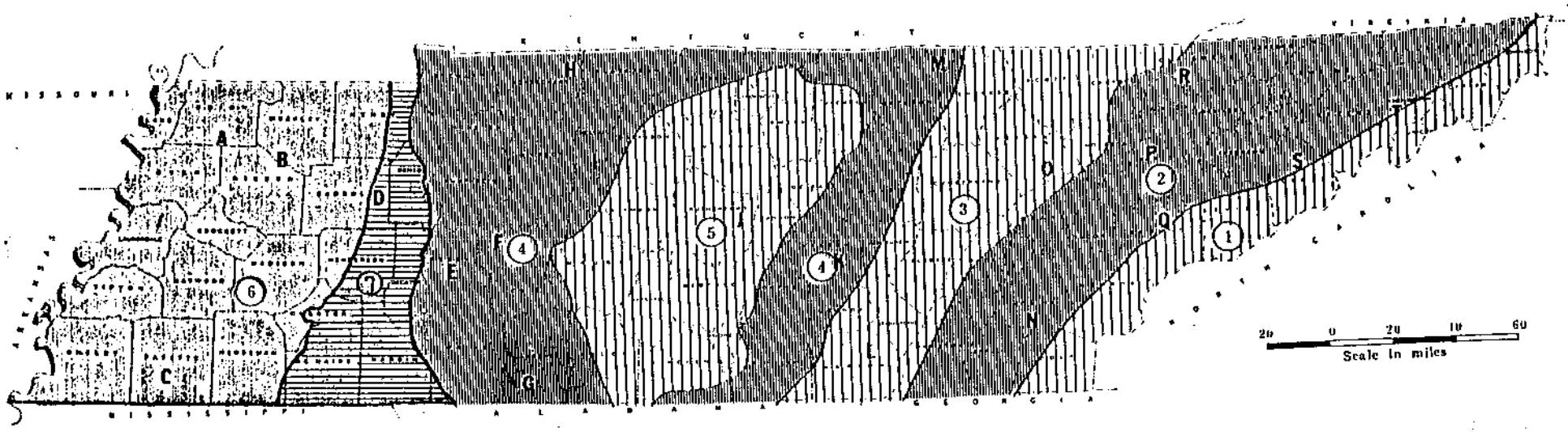
Occurrence Of Surface And Ground Water In Tennessee

The occurrence of surface and ground water in Tennessee is somewhat predictable within physiographically similar areas. Indeed, the severity of drought will vary considerably across the state because of unequal rainfall, varying rates of evapotranspiration, differences in topography and soil, drainage patterns, and geologic formation. In Tennessee, these natural differences in the availability of water have been observed between physiographic areas or provinces of the state. These areas are shown on Figure 3, "Physiographic Provinces of Tennessee." These characteristics are important in terms of an area's general outlook and planned response. Although every source is unique, the availability and quality of water in each province is generally predictable under drought conditions. These conditions are important in considering the impacts to sources from discharges and to their use as sources of water.

In mountainous areas along the eastern edge of Tennessee, potential availability of ground water is fair, due primarily to impermeable rocks that only allow water in cracks and crevices. Minimum surface water flows are usually greater than in other areas of the state due to higher precipitation, immediate runoff and the large number of springs in the region.

Figure 3

PHYSIOGRAPHIC PROVINCES OF TENNESSEE



PROVINCE

1 Blue Ridge
2 Valley and Ridge
3 Cumberland Plateau
4 Highland Rim
5 Central Basin
6 Gulf Coastal Plain
7 Western Valley

Streamflow Monitoring Stations

A. Obion River
B. South Fork Obion River
C. Hatchie River
D. Big Sandy
E. Buffalo River
F. Piney River
G. Shoal Creek
H. Red River
I. Harpeth River
J. East Fork Stones River
K. Collins River
L. Sequatchie River
M. Wolf River
N. Oostanaula River
O. Emory River
P. Bull Run Creek
Q. Little River
R. Clinch River
S. French Broad River
T. Nolichucky River

In the Ridge and Valley province between the eastern mountains and the Cumberland Plateau, ground water is abundant in the valleys as are large quantities of surface water. The province is geologically complex, with ground water availability depending on local topography and geology.

The Cumberland Plateau is a distinct resource area because beds of well-cemented, impermeable sandstone and shale limit ground water availability. Although some formations do yield water, conditions conducive to the occurrence of water have not been adequately studied. Except for the Sequatchie River, streamflows in this province are poorly sustained. Even streams having watersheds exceeding 100 square miles cease to flow at times.

The Highland Rim, the area between the Cumberland Plateau and the western divide of the Tennessee River Basin, excluding the Central Basin area, is underlain by limestone and chert formations favorable for the development of wells with relatively large yields. In addition, these formations sometimes rest on a shale that retards the downward movement of water, giving rise to numerous springs. Streamflows are fairly well sustained in the Highland Rim area.

In the Central Basin, ground water occurs in solution channels and along bedding planes in limestone. Ground water yields are poor, due to thin soils and little underlying porosity in the rock. As a result, streamflows are highly responsive to precipitation and have poorly sustained flows.

The Western Valley of the Tennessee River is underlain by both consolidated rocks and unconsolidated sediments. The province therefore presents a variety in regard to the occurrence of ground water. In some areas ground water occurrence is similar to that in

the Central Basin. In other areas it produces water similarly to the Highland Rim and Coastal Plain provinces.

The Coastal Plain of West Tennessee is underlain by several major aquifers capable of yielding large quantities of ground water. Availability is uniform with declining water levels resulting only in areas of excessive withdrawals. Streamflows are generally well sustained on the western side of the Coastal Plain.

The amount of water available across Tennessee varies seasonally and from one physiographic province to another. Although useful in a general sense to identify drought onset, etc., these descriptions are inadequate when a user's water source must be accurately determined. Where current self-supplied water use needs are easily accommodated by an abundant source, development of a management plan may not be critical; for suppliers of drinking water, it is wise to evaluate each source. The level of risk acceptable to users will determine the extent of hydrologic monitoring needed.

Facility Development As A Risk Element

A system's capacity to treat, store and deliver water under heavy demand must also be evaluated. Improving a system's capacity to deliver requires facility development. Changes in demand and water supply commitments to meet essential uses, including the protection of environmental conditions, must be planned. Greater than normal seasonal demands include shrub, lawn and garden watering, increased water use for personal hygiene and comfort and for swimming pool use. Some increase in demand above normal usage is reasonable. What is important to realize is that systems with adequate "raw" water supplies can still encounter problems if the delivery system is hydraulically inadequate.

Facility development is time consuming and expensive. Facility development should occur when water use is hampered by the delivery system and not by water availability. Water delivery problems include insufficient treatment plant and storage capacity, low water pressure, faulty mains, inadequate line sizes, inadequate pumps, excessive leakage or intake design limits. For example, where a stream does not have a sufficient 3Q20 flow, an impoundment with a ninety-day storage supply of raw water might be necessary. Public water systems should provide for a minimum three-day finished water supply, and treatment capacity should exceed the previous twelve-month average daily water use by 30 percent. Water pressure in distribution lines should be 60 psi and unaccounted water losses through leaks should be within 10 to 12 percent of the treatment plant capacity.

Water users whose supplies do not meet these criteria might have difficulty satisfying water demands during three weeks of peak use.

These criteria are provided to initiate discussion among water users and suppliers. Meeting these criteria will reduce a user's risk for experiencing water shortage, but implementation depends on public acceptance and economic feasibility. There is no single set of remedies appropriate to all users. The more essential the water supply to a user, the greater the need to reduce risk.

Drought management plans must assess risk, differentiating among uses. Acceptable levels of service must be established for various uses and the available water resource managed accordingly. Priorities should be established for essential needs such as hospitals, nursing homes and firefighting. Preference might also be given to domestic uses, livestock watering and office-commercial use. Impacts to the environment should also be considered. Non-essential needs might include lawn watering, car washing and street cleaning. Specific details for the priority of one use over another should be decided by local managers.

Each user or system has its own unique set of demands which must be considered in context. Source and facilities planning should make sense and be cost effective. Because all users are potentially subject to decreases in water availability, due either to a source or facility limitation, development of a local water management plan is critical.

A contingency management plan should take into account the particular characteristics of available sources of water, whether the source is a well, spring, major river tributary, pond or reservoir. Thought should be given to the sources' flow requirements to maintain water quality, aquatic life and other instream uses. Responses must also take into consideration the varied uses of water, their relative importance in terms of livelihoods and the possible conjunctive uses which can be obtained by wise management. Assuming some risk is inevitable because it is not financially feasible to design a water system to meet all demands during an extreme drought. At some point in system development, even a moderate decrease in risk might necessitate great expenditures for new supplies that might rarely be used. In most systems, the necessity for conservation under certain conditions must be accepted.

OPTIONAL DROUGHT MANAGEMENT RESPONSES

Effective responses to drought depend heavily on prior resource planning and development. Many self-supplied individuals, municipalities and industries have planned to mitigate drought. Most industries locate where adequate supplies are known to exist. Cities, unable to locate like industries, have had to build reservoirs, negotiate mutual aid arrangements with other water suppliers or locate other back-up supplies. These responses are generally source related and focus on improving "raw" water availability. They address problems of a diminished resource and not the system's capacity to treat and deliver water. Source related problems brought on by short-term drought would not be acceptable to most communities. However, source related problems during prolonged drought might constitute an acceptable risk for some users.

A system's capacity to deliver water is a second type of problem made worse by dry weather. When higher than normal withdrawals occur, consumer demands for water can simply exceed a treatment system's capacity to deliver. Greater than normal demands include lawn and garden watering, increased use for personal hygiene and comfort, irrigation of golf courses and swimming pool use.

Past Effects Of Drought Preparedness

Long-term drought preparedness has already had an effect in Tennessee. Severity of the 1985-86 drought on many municipalities did not approach the impacts experienced during previous droughts. This is due to improved awareness of source capabilities and uses, and improved preparedness and higher standards of service to communities. Droughts of the early 40's and mid-50's may also have concerned more of the state's population because of heavy impacts on agriculture.

Thus, the user's perceived severity of a drought is affected by the drought's impact upon various activities. Responses to droughts vary and may be perceived differently. Problems requiring development frequently require considerable persistence by managers and planners when users are not under an imminent water shortage threat.

Drought Management Planning

Preparedness Responses

Responses that mitigate water shortages in advance of a crisis generally require both a long lead time and money to implement. These responses include providing adequate supplies of water to meet anticipated growth, as well as sufficient storage to meet essential needs under severe drought conditions. Developing new sources or storage capacity requires time to develop. Other actions must be adapted to specific user needs within the local situation. Once in place, these solutions often significantly reduce the degree of risk assumed by a user.

Drought Responses

Stand-by remedies are actions which individuals, communities and industries take to alleviate inevitable or continuing drought conditions. The actions taken should be identified in the user or purveyor's plan. These solutions tend to be "demand-side" oriented, focusing on water conservation or curtailment rather than on improving water supplies for the long term. During a drought alert industries, self-supplied homeowners, farmers and municipalities might up-date conservation and restrictions phase plans, and monitor supplies when a shortage is possible. Changes in reservoir management at the

federal, state and local levels may be necessary to meet some water demands and/or water quality standards.

Emergency Responses

Emergency or crisis responses consist of those actions which apply to a community or self-supplied user who has or is about to experience a severe shortage of water. In addition, it may include municipal and utility district systems experiencing systemwide or sub-system hydraulic problems.

Responses By Public Suppliers

Public Suppliers - Normal Conditions

Utility district and municipal actions include promotion of water conservation, detection and repair of system leaks and replacement of inefficient water-using equipment. Actions may involve developing a city reservoir, construction of storage tanks, expanding treatment plant capacity and establishing mutual aid agreements with neighboring water suppliers. Another long-term action is adoption of a plumbing code encouraging use of water-saving fixtures.

Although some remedies appear to be spontaneous responses, emergency water supply planning and adoption of ordinances to implement plans in times of drought should be pursued in advance. Study should also include identifying potential water haulers, water hauling equipment, pumps, educational and media materials and perhaps contingency contracts with bottled water suppliers. Study and planning for drought will be more desirable and effective than remedies and ordinances enacted in haste.

Public Suppliers - Alert, Conservation and Restrictions Phases

During a drought municipalities and utility districts can experience both raw water supply and treatment facility problems. Water use curtailment can alleviate both types of problems. Many different measures can reduce water use. Municipalities and utility districts can adopt conservation water pricing structures which encourage decreases in use. Municipalities and utility districts could institute public education programs aimed at reducing water use. Conservation brochures, radio and TV announcements, newspaper releases and public meetings could inform customers on saving water in domestic, landscaping and recreational uses. Municipalities and utility districts could distribute (at public meetings) and/or install toilet tank displacement devices, shower flow restrictors, and replace leaking faucet washers and flappers in commodes in a door-to-door program.

Indoor measures considered under a "conservation" phase might include flushing the toilet fewer times, shorter showers and shallower baths, using washing machines and dishwashers only with full loads or washing by hand, turning the shower off while soaping or shampooing and keeping a bottle of chilled drinking water in the refrigerator.

Outside the home, full curtailment of non-essential water use could be imposed under a "conservation" phase. Restrictions could be imposed on filling (and make-up) of private swimming pools, washing cars, sprinkling lawns and shrubs, use of ornamental fountains and street washing.

Under a "restrictions" phase, municipalities and utility districts could ration water by the week to consumers. A restrictions phase could begin when projected water use exceeds the anticipated thirty-day supply, system hydraulic problems are encountered or the system's conservation goal of a given percent reduction (for example 20%) is not being

met. The basis for rationing could be the number of occupants, with stiff penalties for non-compliance and a five-day service cut-off after two violations. Many systems limit per capita water consumption to fifty gallons per person per day as the allowable amount. In addition, banning of some non-essential and outdoor water uses could be imposed. Watering of lawns might be prohibited, but hand-held application of water to shrubs might be allowed. Utility districts and municipalities could also restrict the time of operations for some industries or require percentage cut-backs from previously established levels of use. Restaurants, hospitals and nursing homes might be required to use disposable paper cups and plates in food service and to serve water only on request.

If water suppliers experience water quality problems due to low flows, additional treatment may be required, or bottled water may be recommended for drinking.

Public Suppliers - Emergency Conditions

Priority users on municipal systems include hospitals, nursing homes, firefighting, domestic drinking water and water for users having livestock. Responses to an emergency or water crisis situation may include running a temporary pipeline to another source, drilling a water well to obtain additional water, and/or hauling water. Suppliers of bottled water may need to supply drinking water to homes temporarily without water. Systems under the emergency phase need to publicize sanitation needs, especially the safe disposal of human waste. Plastic bags and bucket-type containers need to be available. In addition, information about shutting down home water heating systems should be provided.

Responses By Self-Supplied Industry

Self-Supplied Industry - Normal Conditions

Industrial drought preparedness responses include many of the same elements identified for public suppliers. In particular, remedies dealing with wastewater should be considered. These may include developing lagoons or other storage facilities to hold wastewater, additional treatment, increased aeration or other actions requiring special equipment, chemicals or facilities.

Some manufacturers might benefit from water recycling or recovery of rinse or cooling water. Water used in one process may be acceptable for use in subsequent processes. Water conservation in industry frequently results in less effluent which reduces pollutant discharges in low-flow streams. Industries also need to look at water-saving fixtures for employee use, undertake leak detection, and other actions outlined in the next section. Since industrial responses may require considerable planning and water use analysis, they are regarded as actions to be taken over the long term.

Self-Supplied Industry - Alert, Conservation and Restrictions Phases

Industries may require lay offs or cutbacks in production, changes in production schedule, or initiation of water recycling as a result of efforts to conserve water or reduce pollutant loads. Hardships to industries and services that are water intensive may be particularly acute.

Self-Supplied Industry - Emergency Conditions

Industries without water may need to shut down, severely limit operations or seek additional sources of water in cases where overall use is low or primarily for sanitation.

Responses By Agriculture And Domestic Self-Supplied

Agriculture And Domestic Self-Supplied - Normal Conditions

Drought preparedness responses for agriculture include irrigation of crops to obtain better yields. Where precipitation is inadequate and surface or ground water is available, irrigation can be a viable means for managing an agricultural drought. Where irrigation sources are limited, farmers using spray irrigation might convert to a "drip" system to conserve water and reduce evaporative losses.

Livestock owners might develop water wells to provide water to cattle and other animals when ponds, streams and springs become dry. Enlarging ponds and directing runoff from barns and pastures by ditches might be another measure.

Self-supplied homeowners and others relying on springs and water wells should install water-saving fixtures in new construction and whenever fixtures are replaced in existing structures. Plumbing codes in Tennessee generally do not require water-saving devices. Water-saving fixtures include low-volume toilets, low-flow shower heads, lavatory and kitchen faucets with aerators, hot water pipe insulation, and swimming pools with recirculating filtration equipment and pool covers. Purchasing water efficient appliances, such as clothes washing machines, dishwashers and automatic shutoff garden hose devices, can reduce water demand. The use of water-saving devices by self-supplied

users can be very beneficial to users on wells with marginal yields, lessening drawdown of water in well storage. Other actions might include the drilling of an additional water well or connection to a utility district or municipal supply if available. Water management planning for self-supplied users should be coordinated or conducted by local county governments. Actions considered in that planning should include hauling water for drinking and livestock, particularly under emergency conditions.

Agriculture and Domestic Self-Supplied - Alert, Conservation and Restrictions Phases

In addition to monitoring water well levels, springs and streamflows, farmers and other self-supplied users should exercise caution in their water use under a statewide or regional "drought alert." Users must evaluate the stress being placed on their water source by their own use and the uses of others. Where conflicts appear or shortages occur in spite of conservation, users should notify the Office of Water Management. The Office of Water Management could assist in locating additional supplies of water, mediate conflict between users and/or order whatever other actions appear necessary.

Agriculture and Domestic Self-Supplied - Emergency Conditions

Livestock watering tanks need to be convenient and available. Water hauling services should be identified. Responses by self-supplied homeowners will be identical to homeowners served by municipal systems. In some areas, counties may provide a water hauling service to help preserve life, livestock and livelihood.

Fortunately for most communities and self-supplied industries in Tennessee, water supplies are adequate under most drought periods. Tennessee's abundant natural and developed water resources insure that most Tennesseans are minimally impacted by

drought. Shortages in supply generally occur in localized areas. Drought most readily impacts those industries having very large discharges and communities on small tributary streams, as well as a few communities using wells or springs. Self-supplied homeowners and farmers with low-yielding or shallow overburden wells are also more often affected.

Water management actions need to be identified which address specific resource situations. Consistent with this, the "Interim State Drought Management Plan" defines roles that various agencies should use in drought situations.

DROUGHT RESPONSES AND ROLES

Local/Regional Role

Water shortages are best addressed at the local or regional level. Local communities, municipalities, utility districts and county governments can develop water shortage or drought response plans which address local problems and local circumstances. Municipal water systems and other purveyors of water are urged to develop "conservation" and "restriction" phased plans based on a significant scaling back of water availability as well as an "emergency" phase plan for hauling water or other actions necessary to serve customers. Plans should not only consider remedies addressing source related problems, but should also include the provision of drinking water to problem service areas and potential treatment or hydraulic problems. County governments should address hauling water for domestic and livestock use to self-supplied water users with inadequate sources. These plans should address both water supply and water quality. Local water systems should review potential remedies identified in the previous section of this interim plan, the needs of those served by the system and other factors considered relevant.

Because droughts develop slowly, trigger-points for the various stages of management (for example, conservation, restrictions, and emergency) should be identified by individual purveyors. A utility district or municipal drought management plan might require "conservation" measures when likely water supplies appear to be insufficient to meet the anticipated sixty-day demand at the current rate of usage. The plan might impose "restrictions" when water use under "conservation" exceeds the anticipated thirty-day supply and might call for "emergency" measures when restricted water use exceeds the five-day supply. Monitoring of water well levels and measurements of springs, streams and impoundments that trigger plan management phases would have to be organized.

Utility districts and municipal systems are responsible for passing necessary ordinances and standby rate structures as well as for monitoring impoundment supplies, streamflows and ground water levels in production wells. Local systems are expected to establish "conservation" and "restriction" phase goals, identify potential problems in plan implementation and to report to state officials conflicts and problems they may have with other withdrawers, with reservoir management and in meeting water quality permit criteria or standards.

During an extended dry period, local water suppliers may anticipate water quality problems associated with surface water impoundments and low flowing streams. Reductions in water quality due to lower dissolved oxygen levels, higher temperature, increased algae, iron, manganese, or higher concentrations of industrial and municipal waste may result in taste and odor problems or public health hazards. Although the local supplier may not have a problem in supplying quantities of water, action may need to be taken to improve water quality. Remedies will depend on the types of problems encountered. Potential actions could include adjusting chlorine dosage, treating water with activated carbon, potassium permanganate or ozone, or supplying bottled water for drinking.

Local water systems and units of government are responsible for informing customers of conservation measures. Each system is also responsible for informing water users of water use restrictions and, where appropriate, the recycling of water. Enforcement of restrictions and their associated costs (more frequent meter readings, etc.) will be borne by customers of the local system. Systems unable to achieve adopted plan goals and objectives under any phase of implementation would be subject to enforcement action by the Commissioner of the Department of Health and Environment.

Private Sector Role

The role of self-supplied water users is similar to public suppliers in that the provision of water is best addressed by the water user. Water sources and uses should be evaluated and measures should be identified which address water quality and water quantity problems. Where shortages or conflicts appear in source use, users should notify the Office of Water Management for assistance. Remedies appropriate for self-supplied users are largely identical to those listed in the "Conservation," "Restrictions" and "Emergency" response sections of the "Drought Responses" chart found on page 5.

State Role

The state's role in a drought should be to provide water management information, technical assistance and regulatory oversight. Data collection would consist of general indicator data, although water users who depend on monitored sources may benefit specifically. Under existing authority, the Tennessee Office of Water Management will monitor critical steamflow data during drought periods (obtained from the United States Geological Survey through its cooperative program) for specific streams in Tennessee. Data collected and disseminated on a regular basis will include: average mean monthly flow for the period of record, mean monthly flow for the current year, the maximum and minimum daily discharge for the month, and the calculated 3Q20. (A 3Q20 is the estimated low flow for a stream or spring which can be expected to occur over a three-day period once in twenty years.) Data will be collected and made available on a monthly basis to both the public and the Office of Water Management for discharge enforcement purposes. When drought is regional in nature, the release of management information will be targeted.

Because of its delegated authority and mandates, the Office of Water Management should serve as the state focal point for hydrologic data dissemination. For example, reservoir water level data obtained from the Tennessee Valley Authority and the U.S. Army Corps of Engineers will be made available to the public through the Office of Water Management. Ground water levels monitored by the United States Geological Survey will also be obtained and disseminated to the public during drought periods. These data are valuable as indicators of regional ground water levels, which may or may not be applicable to the production wells utilized by individual systems. Also, precipitation data collected by the National Weather Service will continue to be monitored by the Office of Water Management.

When appropriate, the Office of Water Management may issue a local, regional or statewide "drought alert." The alert would call attention to a possible need to curtail water demand. A statewide declaration only alerts users and suppliers of the need to evaluate hydraulic or source stress and the possible need for water conservation measures.

During a "drought alert" the Office of Water Management through its regional field offices will contact weekly those water supply systems and industries considered "drought sensitive" or as "having a potential for a shortage." Their status will be monitored and technical assistance given to the extent possible, including identification of alternative water sources. Water systems that can interconnect with other systems need to be identified.

The Office of Water Management, Division of Water Supply, will solicit and review each system's drought management plan. Within the scope of this interim plan, extensive state directives to guide public suppliers in the development of such plans is not anticipated at this time. Under the State's Safe Drinking Water Act, the Office of Water Management

has authority to supervise operations of public suppliers to insure adequate provision of safe drinking water (T.C.A. Section 68-13-702, et seq., and its Rules and Regulations). Where minimum standards are not being met or compliance with a locally adopted water shortage management plan is inadequate, the supplier would be subject to Orders issued by the Commissioner of the Department of Health and Environment.

The State of Tennessee, through either the Office of Water Management or the Tennessee Emergency Management Agency, will also work with the Tennessee Valley Authority and the Army Corps of Engineers to modify operations of reservoirs and flows deemed necessary to maintain water quality and economic viability as well as serve other purposes. Controlling the availability of water on a regional scale impacts local water supply operations and environmental quality. It must be recognized that pursuing this alternative could adversely affect other uses for which the reservoir system is normally maintained; however, the primary uses adversely impacted would be navigation and recreation.

In circumstances where streamflows cannot be altered or sufficiently improved on a regional scale, the Office of Water Management does have authority to effect some "tradeoffs" among classified water uses. When conditions prevail where competing uses cannot be fully satisfied because of drought conditions, the Office of Water Management is not required to take enforcement action for any violation of stream use criteria. In these instances, the Department would "post" those stream segments not meeting standards. On federal reservoirs, the Department could post those beaches which are unsuitable, thus reducing in effect the priority given to aquatic life and recreation.

Where a local/regional response to a water shortage is inadequate, the Office of Water Management would have authority, either independently or through a concurring

declaration of emergency by the Governor, the Tennessee Emergency Management Agency (TEMA) and the Department of Health and Environment, to mediate or resolve water use conflicts between competing users, including the protection of the environment. In some declared "emergencies" the Office of Water Management may have to allocate water among competing users. The authority for this power can be found under various statutes and Executive Orders (the Civilian Defense Act, T.C.A. Sections 58-2-101 through 58-2-518; the Water Quality Control Act, T.C.A. Section 69-3-109(b); the Safe Drinking Water Act, T.C.A. Section 68-13-710; and Executive Order No. 4).

Situations will be handled locally to the largest extent possible, although state agencies may become involved in coordinating the efforts necessary to alleviate the water crisis. Efforts may be directed toward water hauling, laying of temporary pipe, reallocation of water or any other actions necessary for mitigating the emergency. Each emergency will be dealt with on a case-by-case basis. Where the emergency cannot be resolved by the local water system, the state will consider remedies present within the watershed including the allocation of water between competing users, changes in reservoir management and assistance from nearby systems or communities. Funding of these emergency actions would be borne by the local community to the greatest extent possible.

Federal Role

The role of federal and regional agencies in a drought will depend on the water-related resources under their management. In Tennessee, those federal agencies having major responsibilities include the Tennessee Valley Authority, the U.S. Army Corps of Engineers, the United States Geological Survey, the Environmental Protection Agency, the Fish and Wildlife Service and the Soil Conservation Service. In addition to their obligations to cooperate with the State of Tennessee by providing data on deteriorating water quality

conditions, reservoir level information and changing reservoir management, these agencies should take appropriate steps to cooperate with one another to protect critical habitat and maintain operations. In addition, these agencies should inform recreational users of reservoir hazards due to poor water quality or low water level elevation. Possible water conservation measures at locks could include alternating days of operation, weekend only lockages, or time-of-day restrictions for pleasure craft and/or requiring 75% utilization of lock space before lockage. In some instances, the navigable levels of specified reaches could be reduced if other water use needs would benefit.

In addition, military units in Tennessee should be prepared to provide needed water treatment and water hauling equipment if requested.

CONCLUSION

This interim plan approaches drought basically as a period of more intensive water management dealing with the supply and demand of water. The Office of Water Management recognizes that needs and responses to drought will vary across the state. Droughts affect users differently due to the user's dependence on water, the source involved, the type of drought, the area involved, storage development and many other factors. Therefore, solutions to these many situations must vary.

This interim plan presents a framework for action which is flexible and responsive to the various needs that are likely to emerge in a drought situation. The management strategies developed by individual suppliers and users are extremely important in terms of lessening impacts and delaying or averting further water use restrictions. These strategies involve issues of fairness, hardship and effectiveness.

Future plans should examine more fully a process for dealing with water use conflicts, declaring "limited" or regional water conservation emergencies and providing detailed guidance in the development of local water shortage management plans. Future planning for the management of water under shortage conditions should allow for full participation by public water systems and users in developing specific standards, regulations and procedures.